

WHAT IS CLAIMED:

1. A method for determining an amount of  
bandwidth available in at least one communication path  
5 coupling a plurality of nodes together, the method  
comprising the steps of:

exercising the at least one communication  
path, using information signals, to determine the  
amount of time it takes for at least one of those  
10 information signals to traverse the at least one  
communication path in at least one direction; and

determining an amount of bandwidth available  
in at least a portion of the at least one  
communication path, based on the amount of time  
15 determined in the exercising step.

2. A method as set forth in Claim 1,  
wherein the exercising step includes steps of:

exercising a first, smaller portion of the  
at least one communication path that includes a first  
20 one of the plurality of nodes, using first information  
signals, to determine an amount of signal propagation  
delay present in the first node; and

exercising a second, larger portion the at  
least one communication path that includes the first

node and a second one of the plurality of nodes, using  
second information signals, to determine an amount of  
time it takes for at least one of the second  
information signals to traverse the second, larger  
5 portion of the at least one communication path in at  
least one direction; and

wherein the determining step is performed  
based on both the amount of time determined in that  
exercising step and the amount of signal propagation  
10 delay determined to be present in the first node.

3. A method as set forth in Claim 2,  
wherein the first node is located at a Point of  
Presence, and wherein the bandwidth is in a downlink  
direction in the at least one communication path,  
15 extending from the first node to the second node.

4. A method as set forth in Claim 2,  
wherein the step of exercising the first, smaller  
portion of the at least one communication path  
includes steps of:

20 forwarding individual ones of the first  
information signals from a test node, through the  
first node, and then back again to the test node, by  
way of the first, smaller portion of the at least one  
communication path;

determining the amount of time taken for each individual first information signal to arrive back at the test node, after being forwarded from the test node; and

- 5                   determining a minimum amount of signal propagation delay experienced by the first information signals while passing through the first node, based on the determined amount of time taken for those first information signals to arrive back at the test node;
- 10   and

                  wherein the step of determining the amount of bandwidth available in the at least one communication path is performed based, at least in part, on the determined minimum amount of signal

15   propagation delay.

5.   A method as set forth in Claim 4, wherein the first node includes a router, and the signal propagation delay is caused by a queuing delay in the router.

- 20                  6.   A method as set forth in Claim 4, wherein the step of determining the minimum amount of signal propagation delay is also performed based on at least one of a size of an individual first information signal and a predetermined bandwidth provided between

the test node and the first node.

7. A method as set forth in Claim 2,  
wherein the step of exercising the second, larger  
portion of the at least one communication path using  
5 the second information signals includes the steps of:

forwarding at least one second information  
signal from a test node through the second, larger  
portion of the communication path to the second node,  
to cause that second node to transmit at least one  
10 third information signal back to the test node through  
the second, larger portion of the at least one  
communication path; and

determining a minimum amount of time taken  
for the at least one third information signal to  
15 arrive at the test node, relative to a time when the  
at least one second information signal was forwarded  
from the test node; and

wherein the step of determining the amount  
of bandwidth available in the at least one  
20 communication path is performed based, at least in  
part, on that determined minimum amount of time.

8. A method as set forth in Claim 7,  
wherein the step of determining the amount of  
bandwidth available in the at least one communication

path is performed by executing a predetermined algorithm which is defined as follows:

$$BW_{\text{POP-CPE}} = (PS) / (RTT_{\text{T-CPE}} - ((PS) / BW_{\text{T-POP}}) - 2 * MQD)$$

wherein  $BW_{\text{POP-CPE}}$  represents the amount of  
5 bandwidth available in at least a portion of the at  
least one communication path,  $RTT_{\text{T-CPE}}$  represents the  
minimum amount of time taken for the at least one  
third information signal to arrive at the test node,  
relative to the time when the at least one second  
10 information signal was forwarded from the test node,  
(PS) represents a predetermined size of an individual  
one of the second information signals,  $BW_{\text{T-POP}}$  represents  
a predetermined bandwidth provided between the test  
node and the first node, and MQD represents a  
15 predetermined minimum queuing delay present in the  
first node.

9. A method as set forth in Claim 7,  
wherein the second and third information signals each  
include information packets, and wherein the  
20 information packets of the second information signals  
are substantially larger in size than the information  
packets of the first information signals.

10. A method as set forth in Claim 7,  
wherein the second information signals include

information specifying a predetermined number of hop counts included in the second, larger portion of the at least one communication path, wherein, during the forwarding step, a step is performed of reducing the predetermined number of hop counts specified by the information included in each second signal, based on a number of hops included in the second, larger portion of the at least one communication path, and wherein the second node responds to receiving each individual second signal by further reducing the predetermined number of hop counts specified by the information included in that second information signal, and by then transmitting a corresponding third information signal, based on a result obtained by further reducing that predetermined number of hop counts.

11. A method as set forth in Claim 7, wherein each second information signal includes error-provoking information, and wherein each third signal is an error signal that is transmitted by the second node in response to that second node receiving a corresponding one of the second signals including the error-provoking information.

12. A method as set forth in Claim 11, wherein each third signal is an Internet Control Message Protocol (ICMP) message.

13. A method as set forth in Claim 1,  
further comprising a step of presenting, to a user,  
information indicating the determined amount of  
bandwidth available in the at least one communication  
5 path.

14. An apparatus for determining an amount  
of bandwidth available in at least one communication  
path coupling a plurality of nodes together, the  
apparatus comprising:

10 means for exercising the at least one  
communication path, using information signals, to  
determine the amount of time it takes for at least one  
of those information signals to traverse the at least  
one communication path in at least one direction; and

15 means for determining the amount of  
bandwidth available in at least a portion of the at  
least one communication path, based on the amount of  
time determined in the exercising step.

15. An apparatus for determining an amount  
20 of bandwidth available in at least one communication  
path coupling a plurality of nodes together, the  
apparatus comprising:

a memory storing at least one program;

at least one electronic interface circuit;  
and

5 a controller coupled to said memory and to  
the at least one communication path through said  
electronic interface circuit, said controller  
operating under the control of the at least one  
program stored in said memory for performing (a) an  
exercising operation for exercising the at least one  
communication path by causing information signals to  
10 traverse that path by way of said electronic interface  
circuit, (b) a first determining operation for  
determining, based on the exercising operation, the  
amount of time taken for at least one of those  
information signals to traverse the at least one  
15 communication path in at least one direction, and (c)  
a second determining operation of determining the  
amount of bandwidth available in at least a portion of  
the at least one communication path, based on the  
amount of time determined in the first determining  
20 operation.

16. An apparatus as set forth in Claim 15,  
wherein said controller performs the exercising  
operation by communicating first information signals  
through a first, smaller portion of the at least one  
25 communication path that includes the first node, to



[illegible]

18. An apparatus as set forth in Claim 16,  
20 wherein said controller also operates under the  
control of said at least one program stored in said  
memory by determining the amount of time taken for  
each individual first information signal to arrive  
back at said controller from the first node, after  
25 being communicated by said controller to the first

node, and by determining, based on that amount of time determined for each first information signal, the minimum amount of signal propagation delay experienced by the first information signals while passing through the first node, and wherein said controller performs the second determining operation based on that determined minimum amount of signal propagation delay.

19. An apparatus as set forth in Claim 18, wherein the first node includes a router, and the signal propagation delay is caused by a queuing delay in the router.

20. An apparatus as set forth in Claim 18, wherein said memory also stores first information representing a size of an individual first information signal and second information representing a predetermined amount of bandwidth provided in the first, smaller portion of the at least one communication path coupled between said electronic interface circuit and the first node, and wherein said controller determines the minimum amount of signal propagation delay based also on at least one of the first and second information stored in said memory.

21. An apparatus as set forth in Claim 16, wherein said controller performs the second determining operation by executing a predetermined

algorithm defined as follows:

$$BW_{POP-CPE} = (PS) / (RTT_{T-CPE} - ((PS) / BW_{T-POP}) - 2 * MQD)$$

wherein  $BW_{POP-CPE}$  represents the amount of bandwidth available in at least a portion of the at least one communication path,  $RTT_{T-CPE}$  represents the minimum the amount of time taken for an error message transmitted by a second one of the nodes, to be received by said controller, relative to a time when an error-provoking second information signal was transmitted by said controller, (PS) represents a predetermined size of an individual one of the second information signals,  $BW_{T-POP}$  represents a predetermined bandwidth provided in the first, smaller portion of the at least one communication path coupled between said electronic interface circuit and the first node, and MQD represents a predetermined minimum queuing delay present in the first node.

22. An apparatus as set forth in Claim 15, wherein each of the information signals includes an information packet.

23. An apparatus as set forth in Claim 15, further comprising at least one user output interface coupled to said controller, wherein said controller also operates under the control of said at least one

program stored in said memory for controlling the at least one user interface to cause information indicating the determined amount of available bandwidth to be presented to a user, through that at  
5 least one output user interface.

24. A program product which includes computer-readable code for executing a method to determine an amount of bandwidth available in at least one communication path coupling a plurality of nodes  
10 together, the method comprising the steps of:

exercising the at least one communication path, using information signals, to determine the amount of time it takes for at least one of those information signals to traverse the at least one  
15 communication path in at least one direction; and

determining the amount of bandwidth available in at least a portion of the at least one communication path, based on the amount of time determined in the exercising step.

20 25. A program product as set forth in Claim 24, wherein the exercising step includes steps of:

exercising a first, smaller portion of the at least one communication path that includes a first one of the plurality of nodes, using first information

signals, to determine an amount of signal propagation delay present in the first node; and

exercising a second, larger portion of the at least one communication path that includes the first node and a second one of the plurality of nodes, using second information signals, to determine an amount of time it takes for at least one of the second information signals to traverse the second, larger portion of at least one communication path in at least one direction; and

wherein the determining step is performed based on both the amount of time determined in that exercising step and the amount of signal propagation delay determined to be present in the first node.

26. A program product as set forth in Claim 25, wherein the first node is located at a Point of Presence, and wherein the bandwidth is in a downlink direction in the at least one communication path, extending from the first node to the second node.

27. A program product as set forth in Claim 25, wherein the step of exercising the first, smaller portion of the at least one communication path includes steps of:

forwarding individual ones of the first

information signals from a test node, through the first node, and then back again to the test node, by way of the first, smaller portion of the at least one communication path;

5                   determining the amount of time taken for each individual first information signal to arrive back at the test node, after being forwarded from the test node; and

                  determining a minimum amount of signal  
10   propagation delay experienced by the first information signals while passing through the first node, based on the amount of time taken for those first information signals to arrive back at the test node; and

                  wherein the step of determining the amount  
15   of bandwidth available in the at least one communication path is performed based, at least in part, on the determined minimum amount of signal propagation delay.

28.   A program product as set forth in Claim  
20   27, wherein the first node includes a router, and the signal propagation delay is caused by a queuing delay in the router.

29.   A program product as set forth in Claim  
27, wherein the step of determining the minimum amount

of signal propagation delay is also performed based on at least one of a size of an individual first information signal and a bandwidth provided in the first, smaller portion of the at least one communication path coupled between the test node and the first node.

30. A program product as set forth in Claim 25, wherein the step of exercising the second, larger portion of the at least one communication path using the second information signals includes the steps of:

forwarding at least one second information signal from a test node through the second, larger portion of the at least one communication path to the second node, to cause that second node to transmit at least one third information signal back to the test node through the second, larger portion of the at least one communication path; and

determining a minimum amount of time taken for the at least one third information signal to arrive at the test node, relative to a time when the at least one second information signal was forwarded from the test node; and

wherein the step of determining the amount of bandwidth available in the at least one

communication path is performed based on that  
determined minimum amount of time.

31. A program product as set forth in Claim  
30, wherein the step of determining the amount of  
5 bandwidth available in the at least one communication  
path is performed by executing a predetermined  
algorithm which is defined as follows:

$$BW_{POP-CPE} = (PS) / (RTT_{T-CPE} - ((PS) / BW_{T-POP}) - 2 * MQD)$$

wherein  $BW_{POP-CPE}$  represents the amount of  
10 bandwidth available in at least a portion of the at  
least one communication path,  $RTT_{T-CPE}$  represents the  
minimum the amount of time taken for the at least one  
third information signal to arrive at the test node,  
relative to a time when the at least one second  
15 information signal was forwarded from the test node,  
(PS) represents a predetermined size of an individual  
one of the second information signals,  $BW_{T-POP}$  represents  
a predetermined bandwidth provided between the test  
node and the first node, and MQD represents a  
20 predetermined minimum queuing delay present in the  
first node.

32. A program product as set forth in Claim  
30, wherein the second and third information signals  
each include information packets, and wherein the



information packets of the second information signals are substantially larger in size than the information packets of the first information signals.

33. A program product as set forth in Claim 5 30, wherein each second information signal includes error-provoking information, and wherein each third information signal is an error signal that is transmitted by the second node in response to that second node receiving a corresponding second 10 information signal that includes the error-provoking information.

34. A program product as set forth in Claim 33, wherein each third information signal is an Internet Control Message Protocol (ICMP) message.

15 35. A program product as set forth in Claim 24, wherein the method further comprises a step of presenting, to a user, information indicating the determined amount of bandwidth available in the communication path.

20 36. A communication system, comprising:  
  
a plurality of nodes;  
  
at least one communication path coupling the plurality of nodes together; and

a test node coupled to a first one of said nodes coupled in said communication path, said test node for exercising the communication path by causing information signals to traverse the path by way of said first node, said test node also for determining, based on the exercising operation, the amount of time it takes for at least one of those information signals to traverse the communication path in at least one direction, and for determining an amount of bandwidth available in at least a portion of the communication path, based on the determined amount of time.

37. A communication system as set forth in Claim 36, further comprising at least one network interposed in said communication path between the first node and a second one of the plurality of nodes.

38. A communication system as set forth in Claim 37, wherein the network operates in accordance with one of Frame Relay (FR) technology and Asynchronous Transfer Mode (ATM) technology.

20                    39. A communication system as set forth in  
Claim 37, wherein the test node is coupled to the  
first node through the network, and wherein the first  
node includes a router located at a Point of Presence.

40. A communication system as set forth in

Claim 37, wherein the second node includes a user communication terminal and the first node includes a router located at a Point of Presence.

41. A communication system as set forth in  
5 Claim 40, further comprising a multiplexer/demultiplexer device interposed in said communication path between said network and said second node.

42. A communication system as set forth in  
10 Claim 41, wherein said first node is coupled to the Internet through a further communication path, and wherein the second node is coupled to the Internet through the at least one communication path, said first node, and the further communication path.

43. A communication system as set forth in  
15 Claim 42, wherein said second node communicates using at least one of Asynchronous Digital Subscriber Line (ADSL) technology, Integrated Services Digital Network (ISDN) technology, and wireless technology.

44. A communication system as set forth in  
20 Claim 36, wherein said test node exercises the first node, using information signals, to determine an amount of signal propagation delay present in the first node, and determines the amount of available

bandwidth based on both the determined amount of  
signal propagation delay and the determined amount of  
time.

45. A method for determining an amount of  
5 bandwidth available in at least one communication path  
coupling a plurality of nodes together, the method  
comprising the steps of:

exercising a first portion of the at least  
one communication path in which a first one of the  
10 nodes is coupled, using first information signals, to  
determine an amount time taken for at least one of  
those first information signals to traverse the first  
portion of the at least one communication path, in at  
least one direction;

15 determining an amount of signal propagation  
delay experienced by the at least one first  
information signal while passing through the first  
node, based on the determined amount of time;

exercising at least a second, larger portion  
20 of the at least one communication path, using second  
information signals, to determine an amount of time  
taken for at least one of those second information  
signals to traverse the second portion of the at least  
one communication path, in at least one direction,

wherein the first portion of the at least one communication path forms a portion of the second portion of the at least one communication path; and

determining an amount of bandwidth available  
5 in at least a portion of the at least one communication path, based on the determined amount of signal propagation delay and the amount of time determined in the step of exercising the second, larger portion of the at least one communication path.

10 46. A method as set forth in Claim 45, wherein the bandwidth is available in a portion of the at least one communication path which does not include the first portion of the at least one communication path.

15 47. An apparatus for determining an amount of bandwidth available in at least one communication path coupling a plurality of nodes together, the apparatus comprising:

a memory storing at least one program;  
20 at least one electronic interface circuit;  
and

a controller coupled to said memory and to the at least one communication path through said

electronic interface circuit, said controller  
operating under the control of the at least one  
program stored in said memory for performing (a) a  
first exercising operation of exercising a first  
5 portion of the at least one communication path in  
which a first one of the nodes is coupled, using first  
information signals, to determine an amount time taken  
for at least one of those first information signals to  
traverse the first portion of the at least one  
10 communication path, in at least one direction, (b) a  
first determining operation to determine an amount of  
signal propagation delay experienced by the at least  
one first information signal while passing through the  
first node, based on the amount of time determined in  
15 the first exercising operation, (c) a second  
exercising operation of exercising a second, larger  
portion of the at least one communication path, using  
second information signals, to determine an amount of  
time taken for at least one of those second  
20 information signals to traverse the second portion of  
the at least one communication path, in at least one  
direction, and (d) a second determining operation for  
determining an amount of bandwidth available in at  
least a portion of the at least one communication  
25 path, based on the amount of signal propagation delay  
determined in the first determining operation and the

amount of time determined in the second exercising  
operation,

wherein the first portion of the at least  
one communication path forms a portion of the second  
5 portion of the at least one communication path.

48. An apparatus as set forth in Claim 47,  
wherein the bandwidth is available in a portion of the  
at least one communication path which does not include  
the first portion of the at least one communication  
10 path.

49. A method for determining at least one  
bandwidth available in at least one communication path  
coupling together at least one router and a first  
node, the method comprising the steps of:

15 coupling a second, test node to the at least  
one router;

providing information from the second, test  
to the first node, through the at least one router and  
the at least one communication path;

20 determining an amount of time taken for the  
information to be received in the first node;

determining an amount of the information

received in the first node; and

determining a first bandwidth available in  
at least a portion of the at least one communication  
path, based on the determined amount of time and the  
5 determined amount of the information received in the  
first node.

50. A method as set forth in Claim 49,  
wherein the information includes an electronic file.

51. A method as set forth in Claim 50,  
10 wherein the electronic file has a format in accordance  
with RFC 959.

52. A method as set forth in Claim 49,  
wherein the step of determining the amount of time  
taken for the information to be received in the first  
15 node comprises the steps of:

determining a first, earlier time at which a  
first, beginning portion of the information is  
received at the first node;

determining a second, later time at which a  
20 second, ending portion of the information is received  
at the first node; and

calculating the amount of time taken for the  
information to be received in the first node, based on



the determined first and second times.

53. A method as set forth in Claim 52,  
wherein the step of determining the amount of the  
information received in the first node includes steps

5 of:

counting a number of bytes included in the  
information, as the information is being received in  
the first node, to determine the total number of bytes  
included in the information; and

10 multiplying the number of bytes counted in  
the counting step by a predetermined value to  
determine the total number of bits included in the  
information.

54. A method as set forth in Claim 49,  
15 further comprising the steps of:

providing the information from the first  
node to the second, test node through the at least one  
communication path and the at least one router;

determining an amount of time taken for the  
20 information to be received in the second, test node;

determining an amount of the information  
received in the second, test node; and

determining a second bandwidth available in at least a portion of the at least one communication path, based on that determined amount of time and that determined amount of the information.

5           55. A method as set forth in Claim 54, wherein the step of determining the amount of time taken for the information to be received in the second, test node comprises the steps of:

                  determining a third, earlier time at which  
10   the first, beginning portion of the information is received at the second, test node;

                  determining a fourth, later time at which the second, ending portion of the information is received at the second, test node; and

15           calculating the amount of time taken for the information to be received in the second, test node, based on the determined third and fourth times.

                  56. A method as set forth in Claim 55, wherein the step of determining the amount of the  
20   information received in the second, test node includes steps of:

                  counting a number of bytes included in the information, as the information is being received in

the second, test node, to determine the total number of bytes included in the information; and

5 multiplying the number of bytes counted in that counting step by a predetermined value to determine the total number of bits included in the information.

57. A method as set forth in Claim 54, wherein the first bandwidth is available in the at least one communication path in a direction extending  
10 from the second, test node to the first node, and wherein the second bandwidth is available in the at least one communication path in a direction extending from the first node to the second, test node.

58. An apparatus for communicating with a  
15 node through at least one router and at least one communication path, said apparatus comprising:

a memory storing at least one program;

at least one electronic interface circuit coupled to the at least one router; and

20 a controller coupled to said memory and to the at least one communication path through said electronic interface circuit and the at least one router, said controller operating under the control of

the at least one program stored in said memory, and  
being responsive to receiving information from the  
node through the at least one communication path, the  
at least one router, and the at least one electronic  
5 interface circuit for (a) determining an amount of  
time taken for the information to be received in the  
apparatus, (b) determining an amount of the  
information received in the apparatus, and (c)  
determining a bandwidth available in at least a  
10 portion of the at least one communication path, based  
on the determined amount of time and the determined  
amount of the information.

59. An apparatus as set forth in Claim 58,  
wherein the information is a file having a format in  
15 accordance with RFC 959.

60. An apparatus as set forth in Claim 58,  
wherein the controller is responsive to receiving a  
first, beginning portion of the information for  
determining a first, earlier time at which the first,  
20 beginning portion of the information is received, said  
controller also is responsive to receiving a second,  
ending portion of the information for determining a  
second, later time at which the second, ending portion  
of the information is received, and wherein said  
25 controller determines the amount of time taken for the

information to be received in the apparatus, based on the determined first and second times.

61. An apparatus as set forth in Claim 60, wherein the controller responds to receiving each  
5 individual byte included in the received information, by counting the byte, to determine the total number of bytes included in the information received in the apparatus, and then multiplies the determined total number of bytes by a predetermined value to obtain the  
10 total number of bits included in the information.

62. An apparatus as set forth in Claim 58, wherein the controller also operates under the control of the at least one program for forwarding the information received from the node, back to the node,  
15 by way of the electronic interface circuit, the at least one router, and the at least one communication path.

63. A program product, for use in a computer coupled to a node through at least one router  
20 and at least one communication path, the program product including computer-readable code for executing a method to determine an amount of bandwidth available in the at least one communication path, the method comprising the steps of:

at the computer, detecting the receipt of information forwarded to the computer from the node, through the at least one communication path and the at least one router;

- 5                   determining an amount of time taken for the information to be received in the computer;

                  determining an amount of the information received in the computer; and

- determining a bandwidth available in at  
10   least a portion of the at least one communication path, based on the determined amount of time and the determined amount of the information.

64. A program product as set forth in Claim 63, wherein the information is a file having a format  
15   in accordance with RFC 959.

                  65. A program product as set forth in Claim 63, wherein the detecting step comprises the steps of:

                  detecting a first, beginning portion of the information; and

- 20                   detecting a second, ending portion of the information,

wherein the step of determining the amount of time taken for the information to be received in the computer comprises the steps of:

determining a first, earlier time at which  
5 the first, beginning portion of the information is detected; and

determining a second, later time at which the second, ending portion of the information is detected, and

10 wherein the step of calculating the amount of time taken for the information to be received in the computer is performed based on the determined first and second times.

66. A program product as set forth in Claim  
15 65, wherein the step of determining the amount of the information includes steps of:

counting each byte included in the information to determine the total number of bytes included in the information; and

20 multiplying the determined total number of bytes by a predetermined value to obtain the total number of bits included in the information.

67. A communication system, comprising:

at least one router;

at least one communication path; and

a plurality of nodes coupled together

5 through the at least one communication path and the at  
least one router,

wherein a first one of said plurality of  
nodes provides information to a second one of the  
nodes through the at least one communication path and  
10 the at least one router, and

wherein the first node is responsive to  
receiving the information for (a) determining an  
amount of time taken for the information to be  
received in the first node, (b) determining an amount  
15 of the information received in the first node, and

(c) determining a first bandwidth available  
in at least a portion of the at least one  
communication path, based on the determined amount of  
time and the determined amount of the information.

20 68. A communication system as set forth in  
Claim 67, wherein the first node is responsive to  
determining the first bandwidth for transmitting the  
information back to the second node through the at



least one communication path and the at least one router, and wherein the second node is responsive to receiving that information for (a1) determining an amount of time taken for the information to be  
5 received in the second node, (b1) determining an amount of the information received in the second node, and (c1) determining a second bandwidth available in at least a portion of the at least one communication path, based on that determined amount of time and that  
10 determined amount of the information.

69. A communication system as set forth in Claim 67, wherein the at least one router is located at a Point of Presence of the communication system.